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Large-Scale Dryland Cropping Systems

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Large-Scale Dryland Cropping Systems

Abstract
The change from conventional tillage to no-till cropping systems has allowed for greater intensification of cropping in semi-arid regions. In the central High Plains, wheat-fallow (1 crop in 2 years) has been a popular cropping system for many decades. This system is being replaced by more intensive wheat-summer crop-fallow rotations (2 crops in 3 years). There has also been increased interest in further intensifying the cropping systems by growing 3 crops in 4 years or continuous cropping. The objective of the study was to identify whether more intensive cropping systems can enhance and stabilize production in rainfed cropping systems to optimize economic crop production, more efficiently capture and utilize scarce precipitation, and maintain or enhance soil resources and environmental quality. This project evaluates several multi-crop rotations that are feasible for the region, along with alternative systems that are more intensive than 2- or 3-year rotations. The objectives are to (1) enhance and stabilize production of rainfed cropping systems through the use of multiple crops and rotations using best management practices to optimize capture and utilization of precipitation for economic crop production, and (2) enhance adoption of alternative rainfed cropping systems that provide optimal profitability.

Keywords
dryland cropping, large-scale cropping, semi-arid regions

Cover Page Footnote
This research project received support from the U.S. Department of Agriculture, Agricultural Research Service Ogallala Aquifer Program.

Large-Scale Dryland Cropping Systems

A. Schlegel and L. Haag

Summary

This study was conducted from 2008 to 2017 at the Kansas State University Southwest Research-Extension Center near Tribune, KS. The purpose of the study was to identify whether more intensive cropping systems can enhance and stabilize production in rainfed cropping systems to optimize economic crop production, more efficiently capture and utilize scarce precipitation, and maintain or enhance soil resources and environmental quality. The crop rotations evaluated were continuous grain sorghum (SS), wheat-fallow (WF), wheat-corn-fallow (WCF), wheat-sorghum-fallow (WSF), wheat-corn-sorghum-fallow (WCSF), and wheat-sorghum-corn-fallow (WSCF). All rotations were grown using no-tillage practices except for WF, which was grown using reduced-tillage. The efficiency of precipitation capture was not greater with more intensive rotations. Length of rotation did not affect wheat yields. Corn and grain sorghum yields were about 50% greater when following wheat than when following corn or grain sorghum. Grain sorghum yields were about 40% greater than corn in similar rotations.

Introduction

The change from conventional tillage to no-tillage cropping systems has allowed for greater intensification of cropping in semi-arid regions. In the central High Plains, wheat-fallow (1 crop in 2 years) has been a popular cropping system for many decades. This system is being replaced by more intensive wheat-summer crop-fallow rotations (2 crops in 3 years). There has also been increased interest in further intensifying the cropping systems by growing 3 crops in 4 years or continuous cropping. This project evaluates several multi-crop rotations that are feasible for the region, along with alternative systems that are more intensive than 2- or 3-year rotations. The objectives are to 1) enhance and stabilize production of rainfed cropping systems using multiple crops and rotations, using best management practices to optimize capture and utilization of precipitation for economic crop production, and 2) enhance adoption of alternative rainfed cropping systems that provide optimal profitability.

Experimental Procedures

The crop rotations are 2-year (wheat-fallow [WF]); 3-year (wheat-grain sorghum-fallow [WSF] and wheat-corn-fallow [WCF]); 4-year rotations (wheat-corn-sorghum-fallow [WCSF] and wheat-sorghum-corn-fallow [WSCF]); and continuous sorghum [SS]). All rotations are grown using no-tillage (NT) practices except for WF, which is grown using reduced-tillage (RT). All phases of each rotation are present each year. Plot size is a minimum of 100 × 450 ft. In most instances, grain yields were determined by harvesting the center 60 ft (by entire length) of each plot with a commercial combine and determining grain weight with a weigh-wagon or combine yield monitor. Soil water was measured in 12-inch increments to 96 inches near planting and after harvest either gravimetrically (RT WF) or by neutron attenuation (NT plots).

Results and Discussion

Precipitation averaged 101% of normal (17.90 in.) across the 10-yr study period and was near normal (+/- 15%) in 6 out of 10 years with three wet years (>20% above normal) and one exceptionally dry year (42% of normal) (Figure 1). Fallow accumulation, fallow efficiency, and profile available water at wheat planting was greater with WF than all other wheat rotations (Table 1). The fallow efficiencies of the 3- and 4-yr NT rotations were only 50-68% of WF under RT. With more water available, crop water use was also greater with WF than with wheat in other rotations. There were no differences in available water at wheat planting or crop water use among the 3- and 4-yr rotations.

Fallow accumulation prior to corn planting and profile available soil water at planting was greater following wheat (WCF or WCSF) than following grain sorghum (WSCF) (Table 1). However, the fallow period following wheat was longer, resulting in low fallow efficiencies (~17%) following wheat and only 25% following sorghum. Similar to wheat, corn water use was greater with greater available soil water at planting. Grain sorghum responded similarly to corn, with greater fallow accumulation and soil water at planting (and greater crop water use) when following wheat than following corn or sorghum. Again, fallow efficiencies prior to grain sorghum were low (16-23%).

Wheat yields were lower than normal in 2017 because of damage from wheat streak mosaic virus (Figure 2). The effect of cropping systems was not consistent across years with WF sometimes in the highest yielding group and sometimes in the lowest yielding group. Averaged across the 10 years, cropping system had little effect on wheat yields.

Grain sorghum yields were very good in 2017 with all treatments producing yields of 135 bu/a or greater (Figure 3). In contrast to previous years, grain sorghum yields following corn or sorghum were not much lower than following wheat. However, average grain sorghum yields following wheat were about 50% greater than following corn or sorghum.

Corn yields were also very good in 2017 (Figure 4) with all rotations yielding 115 bu/a or more. Corn yields following wheat in either the 3- or 4-yr rotations were always greater than corn yields following grain sorghum, except in 2015 where corn yields following sorghum (wsCf) were greater than wCf. On average, corn yields following wheat were about 50% greater than following grain sorghum.

When examining grain yields across crops, the greatest yields were produced by grain sorghum following wheat (either wSf or wScf) of about 80 bu/a (Figure 5). These yields were about 40% greater than corn following wheat (wCf or wCsf). Sorghum yields following wheat were about 50% greater than sorghum following corn or sorghum (wcSf or SS) while corn yields following wheat (wCf or wCsf) were also about 50% greater than following sorghum.

Acknowledgments

This research project received support from the U.S. Department of Agriculture, Agricultural Research Service Ogallala Aquifer Program.

Table 1. Fallow accumulation, fallow efficiency, profile (8 ft) available soil water at planting, and crop water use by wheat, corn, and grain sorghum in several crop rotations, Tribune, KS, 2008-2017

Crop	Rotation	Fallow accumulation	Fallow efficiency	Profile ASW at planting[2]	Crop water use
		inch	%	----------------inch----------------	
Wheat	Wf[1]	6.90a	28a	9.80a	18.21a
	Wsf	2.91bc	18b	6.10b	13.89b
	Wcf	2.42c	14c	5.88b	13.77b
	Wscf	3.26b	19b	6.41b	14.13b
	Wcsf	3.00b	18b	6.17b	13.98b
$LSD_{0.05}$		0.54	3	0.64	0.56
Corn	wCf	2.62a	18b	5.82a	13.81a
	wCsf	2.49a	17b	5.77a	13.80a
	wsCf	1.70b	25a	4.84b	12.99b
$LSD_{0.05}$		0.39	3	0.59	0.39
Grain sorghum	wSf	2.43b	16c	5.80a	13.16b
	wScf	3.09a	19b	6.32a	13.56a
	wcSf	1.57c	18bc	5.02b	12.56c
	SS	2.09b	23a	5.22b	12.61c
$LSD_{0.05}$		0.36	3	0.56	0.37

[1]Wheat-fallow rotation is reduced-tillage; all other rotations are no-tillage. Means within a column with the same letter for the same crop are not statistically different at $P = 0.05$. The capital letter in the rotation denotes the crop phase of the rotation.
[2]Available soil water (ASW) in an 8 ft profile at planting.
W = wheat; F = fallow; S = sorghum; C = corn; SS = continuous grain sorghum.

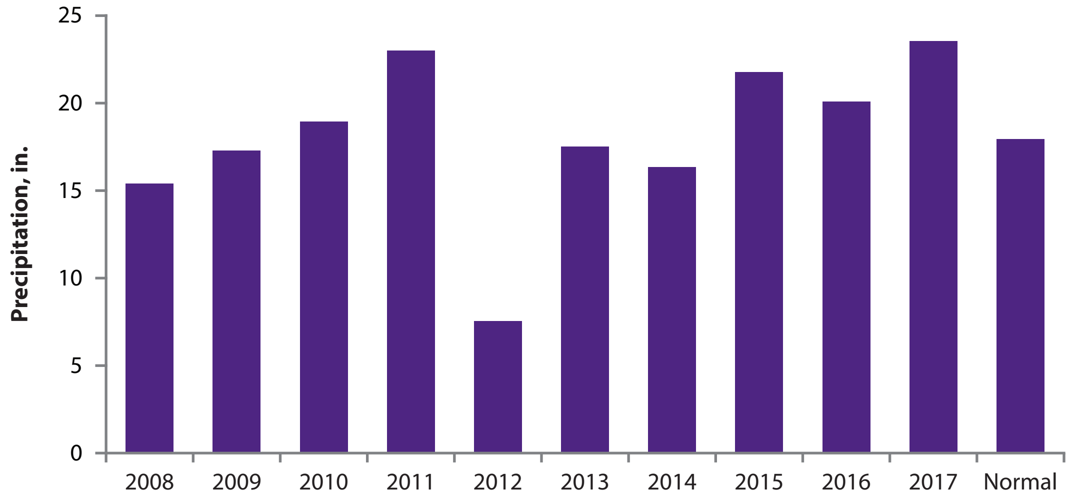

Figure 1. Annual (2008-2017) and normal precipitation (1981-2010, last bar), Tribune, KS.

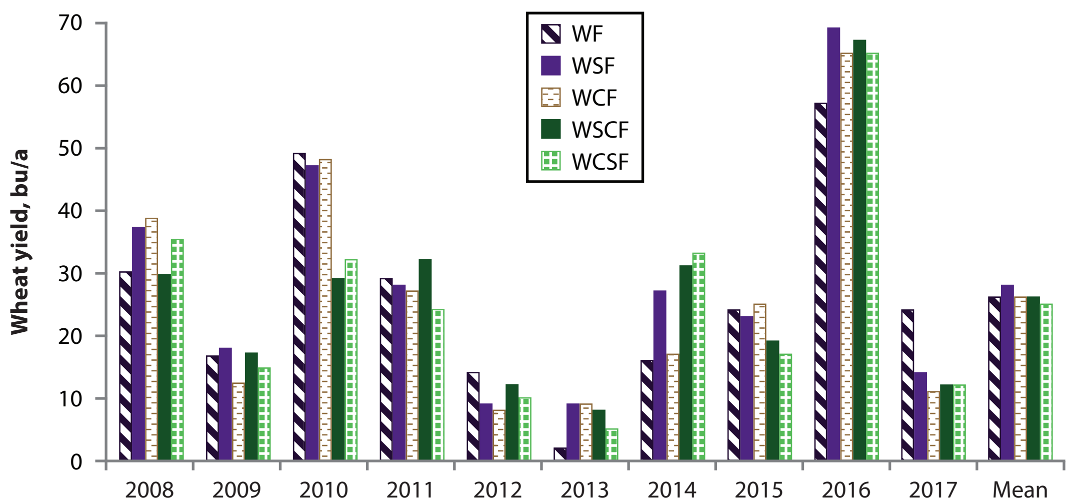

Figure 2. Wheat yields by cropping system, 2008-2017. Last set of columns are treatment means. Wheat-fallow (WF), wheat-sorghum-fallow (WSF), wheat-corn-fallow (WCF), wheat-corn-sorghum-fallow (WCSF), and wheat-sorghum-corn-fallow (WSCF).

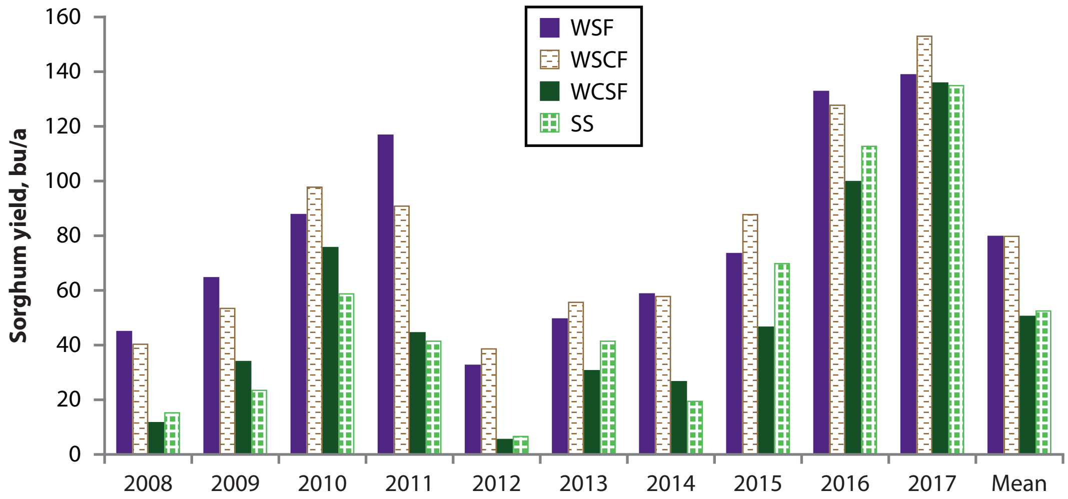

Figure 3. Grain sorghum yields by cropping system, 2008-2017. Last set of columns are treatment means. Wheat-sorghum-fallow (WSF), wheat-sorghum-corn-fallow (WSCF), wheat-corn-sorghum-fallow (WCSF), and continuous grain sorghum (SS).

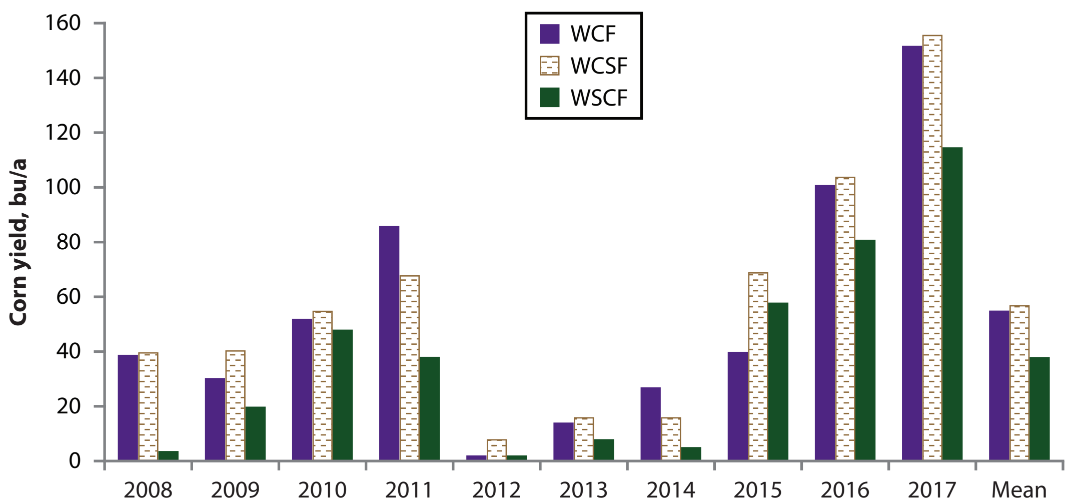

Figure 4. Corn yields by cropping system, 2008-2017. Last set of columns are treatment means. Wheat-corn-fallow (WCF), wheat-corn-sorghum-fallow (WCSF), and wheat-sorghum-corn-fallow (WSCF)

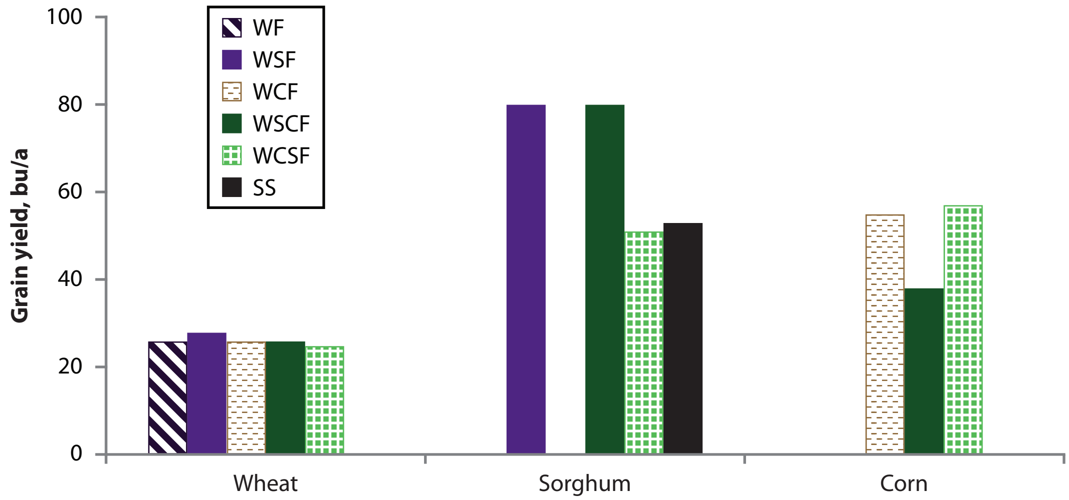

Figure 5. Average grain yields by cropping system, 2008-2017. Wheat-fallow (WF), wheat-sorghum-fallow (WSF), wheat-corn-fallow (WCF), wheat-sorghum-corn-fallow (WSCF), wheat-corn-sorghum-fallow (WCSF), and continuous grain sorghum (SS).